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DEVELOPMENT OF ELECTRONICALLY-TUNABLE  
CONVERTERS IN THE MILLIMETER-WAVE RANGE  
(NASA CONTRACT NASw-790)  
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CONTRACT NASw-790

DEVELOPMENT OF ELECTRONICALLY-TUNABLE  
CONVERTERS IN THE MILLIMETER WAVE-RANGE

I. INTRODUCTION

Under this contract, the contractor shall conduct an experimental program for the development of electronically-tunable converters in the millimeter wave range. The work program in accordance with the statement of work has been summarized into four tasks as follows:

Task A

Investigate the intermediate-frequency effect on the conversion gain of a single-circuit converter.

Task B

Experimentally determine the characteristics of ridge-loaded, meander-line circuits partially or totally wrapped into a circular configuration.

Task C

Design and construct special purpose, backward-wave tubes in the 50 to 75 Gc range, suitable for operation as an oscillator, amplifier, or single-circuit converter.

Task D

Design and construct three double-circuited experimental backward-wave converters for operation in the 50 to 75 Gc frequency range. This shall be accomplished after completion of Task C.

At the present time the essential work on Tasks A and B has been completed and the effort on Task C is well under way.

## II. WORK ACCOMPLISHED DURING THE PAST INTERVAL

### Task A

During the past interval, another attempt was made to resolve the discrepancy between experiment and theory of the single circuit converter (Figure 1, Bimonthly Report No. 2). Both theory and experiment were investigated.

The theoretical curves of  $F$  (which is proportional to the i-f current in the beam,  $i_d$ ) as a function of  $f_d/f_a$  were based on the assumption that the gain of the helix as an r-f amplifier was inversely proportional to the i-f. This is not exactly true in practice so the amplifier gain as a function of i-f was measured on the F-2524 tube. The resulting data is to be used as new input for the computer solutions of  $F$  as a function of  $f_d/f_a$  and should result in more realistic theoretical curves.

The two major problem areas in the experimental phase are inter-related. One concerns the validity of the measurement of  $i_d$  and is dependent upon a knowledge of the value of the i-f load impedance. The other is of a more practical nature and involves extracting as much i-f power as possible by making the i-f load resistance as large as possible.

In the past, the load apparently has been limited to 50 ohms by the 50 ohm input impedance of standard measuring equipment. In most instances a spectrum analyzer was used. In order to obviate this problem, a vacuum tube circuit, using a cathode follower output, was made to isolate the input impedance of the spectrum analyzer from the i-f circuit. This should have allowed a high i-f load to be used. It was discovered, however, that the i-f impedance now was being limited by the distributed capacitance of the i-f collector and cable. It was measured (at 60 Mc/s) to be 50 pfd which is 53 ohms of shunt reactance at 60 Mc/s. Two steps are apparent to make possible a high i-f load:

One, minimize the cable length to minimize the shunt capacity and, two, cancel (by resonance) the shunt capacity with a shunt inductance (a physical inductor at the lower frequencies and a shorted coaxial cable slightly less than  $\lambda/4$  long at the higher frequencies).

The awareness of the presence of distributed capacity has placed in doubt the value of the previous measurements. The load, as it was used previously, obviously was frequency sensitive but in making calculations the load had been assumed constant. In addition to this, the presence of distributed inductance could cause system resonances which, in turn, would cause high effective load impedance. (Only .14  $\mu$ h are needed to resonate 50 pfd at 60 Mc/s.)

It appears that what must be done is to use resonant i-f loads at discrete frequencies in order that both a high load impedance can be obtained and that its value can be determined with a reasonable degree of accuracy.

#### Task B

During the third report period the slow wave structure for the tubes of Task C and D was chosen. The design of the structure was based on a series of calculations involving beam and circuit diameters and the results of measurements on cold test structures which bracketed the design. While the performance of the structure is known in general it was decided that an accurate tuning curve and impedance plot would be valuable for predicting the performance and checking the results of the final tubes. Therefore during the past interval an exact model cold test structure was ordered.

#### Task C

During the past interval the bulk of the parts and fixtures for the Task C tube were received and work on the machining of the slow wave structure was begun. From what has been learned thus far this will be one of the most

difficult phases of the program. While it is not too difficult to set up and machine a structure the problem is one of obtaining the precise uniformity and degree of surface finish, required for minimum r-f losses. During the past period a number of test machinings were conducted on short sections of structure for various spark machining conditions. We are presently able to reproduce a good finish and are setting up to machine a full length circuit for the first tube. Figure 1 is a photograph of a test circuit in which one of the circuit blocks has been set back so that the details of the circuit and the waveguide feeds may be seen.

#### Task D

During the past interval an electron gun for the Task D tubes was designed and parts ordered for test. This gun differs from the more conventional gun of Task C in that it is designed specifically for low noise operation. The gun also differs from the ordinary low-noise gun in that it must operate over an extended voltage range as dictated by the tuning characteristics of the slow wave circuit. The initial test on this gun will be a beam transmission test.

### III. PROGRAM FOR THE NEXT INTERVAL

#### Task A

The theory of the single circuit converter indicates that conversion gains in excess of -40 db are not readily obtainable. Because of this, further investigation of single-circuit converter behavior has little value to anyone. However, since the i-f circuit problem must be resolved, one final measurement on the single circuit converter, using improved i-f circuitry, will be made. This i-f circuit will consist of the beam collector, across which a high (known) impedance is placed, followed by the vacuum tube impedance isolater, the cathode follower output of which feeds the spectrum analyzer.

The results of this measurement will be compared to new theoretical results. However, as further investigation will be beneficial to no one, we will consider Task A to be completed at this point.

Task B

The measurements on the cold test structure will be completed and available for comparison with the results of the Task C tubes.

Task C

During the next interval the major effort will be on this task. It is expected that the first circuit will be completed during the next few weeks and that the first tube will be completed shortly thereafter.

Task D

During the next interval parts and fixtures for the final tubes will be ordered. Since most of the parts of the Task C and D tubes are common, the ordering will involve only those few items which are different. A reorder of common parts will not be necessary since a sufficient number were ordered originally on Task C.

Tests of the low noise gun will be completed during April.

